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What is claimed is:

1. A magnetically latched solenoid assembly comprising:

a housing, said housing supporting;

5 a solenoid subassembly and a magnetically latching subassembly laterally spaced from said solenoid subassembly, said solenoid subassembly comprising;

an electromagnetic coil, a tubular mandrel supporting said coil and including a through-bore, a
10 moveable armature having at least a portion thereof supported by and longitudinally moveable within said mandrel through-bore and being responsive to electrical energization of said coil;

a stationary magnetic pole piece located proximate
15 to one end of said mandrel through-bore;

an operating member secured to and arranged for concurrent movement of said armature;

said magnetic latching subassembly comprising;

a magnet holder slidably received by said housing, a
20 magnetic coupling member secured to said operating member and arranged for minimal air gap magnetic latching engagement with said magnet holder upon longitudinal movement of said armature and said operating member;

said magnetic latching subassembly further
25 comprising;

at least one permanent magnet; and

biasing means arranged to momentarily prevent impact
movement of said coupling member relative to said
permanent magnet subassembly resulting from abutting
30 engagement between said movable armature and said stationary pole piece, and for such time that magnetic attraction between said stationary magnet subassembly and said coupling member has reached sufficient force to overcome the bias of said biasing member and the magnetic
35 reluctance of said minimal air gap.

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2. A bi-directional solenoid comprising a tubular housing, said housing including;

first and second axially spaced solenoid assemblies supported by said housing, said solenoid assemblies each comprising an electromagnetic coil and coil supporting mandrel, each of said mandrels containing a through-bore, and a magnetic armature slidably received by a respective mandrel through-bore, and a reciprocally moveable operating member secured to each of said armatures and alternatively axially moveable upon movement of a respective armature responsive to electrical energization of a respective one of said coils;

a stationary magnetic pole piece located intermediate said solenoid subassemblies, and

a first and a second magnetic latching subassembly, each of said magnetic latching subassemblies being respectively longitudinally spaced from said first and said second solenoid subassemblies;

each of said magnetic latching subassemblies comprising;

a longitudinally moveable permanent magnet subassembly containing at least one permanent magnet,

a magnetic coupling member arranged for minimal air gap magnetic latching engagement with said longitudinally moveable permanent magnet subassembly upon longitudinal movement of said armature, and

biasing means arranged to momentarily prevent impact movement of said coupling member relative to said permanent magnet-subassembly resulting from abutting engagement between said moveable armature and said stationary pole piece, and for such time that magnetic attraction between said longitudinally moveable permanent magnet subassembly and said coupling member has reached sufficient force to overcome the bias of said biasing

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member and the magnetic reluctance of said minimal air gap.

3. A magnetic latching solenoid comprising a housing, said housing containing:

5 a solenoid assembly, said solenoid assembly including;

a wound electromagnetic coil,

a stationary magnetic pole piece,

10 a magnetic armature operated by said coil and movable in a direction towards said pole piece, and

an operating rod secured to and movable with said magnetic armature; and

15 a permanent magnetic latching assembly, said magnetic assembly including a permanent magnet latching circuit structure comprising a magnet holder and a permanent magnet secured to and supported by said magnet holder,

20 a magnet coupling member mechanically secured to said solenoid armature and movable therewith and being arranged to magnetically mate with said magnetic latching circuit structure upon abutting contact of said armature with said stationary pole piece, and thereby establish a minimal air gap between said coupling member and said permanent magnet latching structure, and

25 biasing means arranged to bias said coupling member in a direction away from mating contact with said permanent magnet latching structure, and whereby upon achieving abutting contact between said armature and said stationary pole piece, the permanent magnet attraction between said coupling member and said magnetic latching circuit structure is sufficient to overcome the biasing force exerted by said biasing means.

4. A magnetic latching solenoid comprising:

a housing, said housing containing;

35 a solenoid assembly, a stationary magnetic pole

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piece laterally spaced from said solenoid assembly and a magnetic latching assembly laterally spaced from said solenoid assembly and from said pole piece;

said solenoid assembly including;

5 a nonmagnetic tubular mandrel having bore and having a first and a second end, said first end terminating at and supported by said stationary magnetic pole piece;

a bobbin-wound coil positioned circumjacent to and supported by said nonmagnetic tube;

10 a magnetic armature plunger, said plunger being slidably received by the bore of said nonmagnetic tube, said armature plunger having one end normally abutting said magnetic pole piece; and

an operating rod secured to said armature plunger and extending outwardly of said housing;

15 said magnetic latching assemblies including;

a magnet retaining subassembly, said subassembly comprising;

20 an outer magnet holder supported by said housing and including a through bore arranged to receive and secure a middle magnet holder, said middle magnet holder including a threaded bore and at least one inwardly facing cavity, at least one permanent magnet disc residing in said cavity, an inner magnet holder abutting said permanent magnet disc and including a through bore, and a threaded clamping screw seated within the bore of said inner magnet holder and threadingly engageable with the threaded bore of said outer magnet holder;

25 a helical coiled biasing spring having a longitudinal portion surrounding said middle magnet holder, said middle magnet holder and said longitudinal portion being seated within the recessed area of said outer magnet holder, and the remaining longitudinal portion of said biasing spring extending inwardly of said housing;

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a magnetic coupling member including a reentrant recessed area arranged to receive the innermost coil of the remaining longitudinal portion of said biasing spring, said coupling member including a flat, inwardly facing surface arranged for abutting contact with the outwardly facing end surface of said armature plunger for cushioning movement of said coupling member against the bias of said coiled spring and with the outwardly facing surface of said coupling member being arranged for magnetic latching contact with the inwardly facing surface of said inner magnet holder, said magnetic coupling member, when in closed latching position relative to said inner magnet holder, providing a substantially zero air gap between said coupling member and said inwardly facing.

5. The magnetic latching solenoid of claim 4, wherein said biasing means comprises a coiled compression spring located between said magnetic coupling member and said permanent magnet latching structure.

6. The magnetic latching solenoid of claim 4, wherein said permanent magnet latching circuit structure comprises a magnet holder and an array of a plurality of equally spaced disc magnets.

7. A bi-directional dual magnetic latching solenoid comprising a housing, said housing containing:

a stationary magnetic pole piece;

a pair of solenoid assemblies, each of said solenoid assemblies being spaced from opposite sides of said stationary pole piece and each of said solenoid assemblies including;

a wound electromagnetic coil;

a pair of magnetic armatures, each armature of said pair of armatures being operated by a respective one of said coils and being alternatively movable in a direction towards said pole piece; and

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an operating rod secured to and alternatively movable with each of said magnetic armatures;

magnetic armature operated by a respective one of said coils and being movable in a direction towards said pole piece;

an operating rod secured to and alternatively movable with each of said magnetic armatures; and

a magnetic coupling member mechanically secured to a respective one of said pair of said solenoid armatures and movable therewith, said coupling member being arranged to magnetically mate with said magnetic latching circuit structure upon abutting contact of a respective one of said pair of armatures with said stationary pole piece, and thereby establishing minimal air gap between said coupling member and said permanent latching circuit structure; and

biasing means arranged to bias a respective one of said coupling members in a direction away from mating contact with its respective permanent magnet latching structure, and whereby upon achieving abutting contact between a respective one of said armatures and the side of said stationary pole piece, the permanent magnet attraction between said coupling member and its respective magnetic latching circuit structure is sufficient to overcome the biasing force exerted by said biasing means.

8. A magnetic latching solenoid comprising:

a housing, said housing containing;

a solenoid assembly, a stationary magnetic pole piece axially spaced from said solenoid assembly, and a magnetic latching assembly axially spaced from said solenoid assembly and from said pole piece;

said solenoid assembly including;

a nonmagnetic tubular mandrel having a bore and having a first and a second end, said first end

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terminating at and supported by said stationary magnetic pole piece;

an electromagnetic coil positioned circumjacent to and supported by said nonmagnetic tube;

5 a magnetic armature plunger, said plunger being slidably received by the bore of said nonmagnetic tube, said armature plunger having one end normally abutting said magnetic pole piece; and

10 an operating rod secured to said armature plunger and extending outwardly of said housing;

a magnetic latching assembly including;

a magnet retaining subassembly, said subassembly comprising;

15 an outer magnet holder supported by said housing and including a through bore arranged to receive and secure a middle magnet holder, said middle magnet holder including a threaded bore and at least one inwardly facing cavity, at least one permanent magnet disc residing in said cavity, an inner magnet holder abutting said permanent magnet disc and including a through bore, and a threaded clamping screw seated within the bore of said inner magnet holder and threadingly engageable with the threaded bore of said outer magnet holder;

20 a helical coiled compression spring having a longitudinal portion surrounding said middle magnet holder, said middle magnet holder and said longitudinal portion being seated within the recessed area of said outer magnet holder, and the remaining longitudinal portion of said spring extending inwardly of said housing;

30 a magnetic clapper member including a reentrant recessed area arranged to receive the innermost coil of the remaining longitudinal portion of said spring, said clapper member including a flat, inwardly facing surface arranged for abutting contact with the outwardly facing

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end surface of said armature plunger for cushioning movement of said clapper member against the bias of said coiled spring and with the outwardly facing surface of said clapper member being arranged for magnetic latching contact with the inwardly facing surface of said inner magnet holder, said magnet clapper member, when in closed latching position relative to said inner magnet holder, providing a substantially zero air gap between said clapper member and said inwardly facing surface.

9. The magnetic latching solenoid of claim 4 wherein the at least one permanent magnet disc is of rare earth material.

10. A magnetic latching solenoid comprising:

a magnetic tubular housing containing a through bore, said housing including;

a solenoid assembly, a stationary magnetic pole piece spaced inwardly from said solenoid assembly and a magnetic latching assembly spaced outwardly relative to said solenoid assembly;

said solenoid assembly including;

a magnetic tubular mandrel having bore and extending coaxially relative to said housing bore and having a first and a second end, said first end terminating at and supported by said stationary magnetic pole piece;

a bobbin-wound coil positioned circumjacent to and supported by said non-magnetic tube;

a magnetic armature plunger having a through bore, said plunger being slidably received by the bore of said non-magnetic tube, said armature plunger having one end normally abutting said magnetic pole piece and having its opposite end lying substantially coplanar with the plane intersecting the second end of said non-magnetic tube, said plane being substantially normal to the longitudinal axis of said tubular housing; and

an operating rod slidably received by the bore of

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said magnetic pole piece and being secured to said armature plunger;

said magnetic latching assembly including;

5 a permanent magnet retaining subassembly, said subassembly comprising;

a longitudinally inwardly moveable outer magnet holder slidably supported by said tubular housing and arranged to normally provide a pre-determined axial gap within said housing, said outer magnet holder including a
10 through bore arranged to receive and secure a middle magnet holder, said middle magnet holder including a threaded bore and at least one inwardly facing cavity, at least one permanent magnet disc residing in said cavity, an inner magnet holder abutting said permanent magnet
15 disc and including a through bore, and a threaded clamping screw seated within the bore of said inner magnet holder and threadingly engageable with the threaded bore of said outer magnet holder;

a helical coiled compression spring having a
20 longitudinal portion surrounding said middle magnet holder, said middle magnet holder and said longitudinal portion being seated within the recessed area of said outer magnet holder, and the remaining longitudinal portion of said compression spring extending inwardly of
25 said housing;

a magnetic clapper member slidably received by the bore of said tubular housing and including a reentrant recessed area receiving the innermost coil of the remaining longitudinal portion of said biasing spring,
30 said clapper member including a flat, inwardly facing surface arranged for abutting contact with the outwardly facing end surface of said armature plunger for biasing movement of said clapper member against the bias of said coiled spring, and with the outwardly facing surface of
35 said clapper member arranged for magnetic latching

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5 contact with the inwardly facing surface of said inner magnet holder, said magnetic clapper member, when in closed latching position relative to said inner magnet holder, providing a substantially zero air gap between said clapper member and said inwardly facing surface of said inwardly moveable magnet holder.

11. The magnetic latching solenoid of claim 6 wherein at least one permanent magnet disc is of rare earth material.

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